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HIDDEN VARIABLES AND QUANTUM STATISTICS NATURE

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It is shown that the nature of quantum statistics can be clarified by assuming the existence of a background of random gravitational fields and waves, distributed isotropically in the space. This background is responsible for correlating phases of oscillations of identical microobjects. If such a background of random gravitational fields and waves is considered as hidden variables then taking it into account leads to the Bell-type inequalities that are fairly consistent with the experimental data.

Quantum theory is a statistical theory, which at the same time does not lend itself to investigation of its statistics nature, this problem being considered as being beyond its scope. Quantum theory does not deal with the causes of quantum phenomena; it postulates the classically inexplicable phenomena of a quantum microcosm observed in experiments as its axioms. Such an approach, although not introducing errors, does not explain the experimentally observable phenomena, leaving them incomprehensible from the classical viewpoint and giving rise to all sorts of paradoxes. Quantum theory lacks the classical logic and the classical causality, hence the classical axiomatics, which makes this theory, from the classical physics viewpoint, rely on the method of indirect computations.

Are classical causality and classical logic absent in quantum theory only or in nature as well? The absence of classical causality and classical logic in the theory does not imply their absence in the nature.

Now, let us try to single out the basic classically incomprehensible concepts of quantum theory. First, it is the wave-particle dualism. Taking into account all the above-mentioned, a particle could acquire wave properties, being influenced by a wave background. Second, it is Heisenberg's uncertainty principle. Due to the influence of nonremovable background on a measurement, it is impossible to measure the values precisely. Third, it is the energy balance in an atom. From the classical physics viewpoint, an electron moving in the electric field of the nucleus should emit electromagnetic radiation. Can we assume that the background of the whole spectrum of frequencies gives energy to the electron, the latter re-emitting it, and that the energy balance in the atom could then be maintained?

We can complete quantum theory with hidden variables without altering the mathematical apparatus of quantum mechanics. Does a comprehensible theory result?

The issue of the necessity to complete the quantum theory was first considered in the study by A. Einstein, B. Podolsky and N. Rosen (hereinafter, EPR) [1]. Let us consider the EPR effect. Two particles, A and B, at the initial moment interact and then scatter in opposite directions. Let the first of them be described by the wavefunction ψ_A, the other one by ψ_B. The system of the two particles A and B is described by the wavefunction ψ_{AB}. With this,

$$\psi_A \neq \psi_{AB},\ \psi_B \neq \psi_{AB},\ \psi_{AB} \neq \psi_A\psi_B, \text{ or, } P_{AB} \neq P_A P_B.$$

For independent events P_A and P_B, according to probability theory,

$$P_{AB} = P_A P_B.$$

Where could the dependence of the object A on the object B and vice versa originate from, these objects A and B being considered as distant and noninteracting? The EPR authors arrived at the conclusion on the incompleteness of the quantum–mechanical description. To solve this contradiction, an idea has been put forward in [1] on the existence of hidden variables that would make it possible to interpret consistently the results of the experiments without altering the mathematical apparatus of quantum mechanics.

Later, it has proved by von Neumann [2] that quantum mechanics axiomatics does not allow the introduction of hidden variables. It is, however, important that the argument presented in [2] is not valid in certain cases, e. g., for pairwise observable microobjects (for Hilbert space with pairwise commutable operators) [3]. In 1964, J. S. Bell [4] formulated an experimental criterion enabling to decide, within the framework of the problem statement [1], on the existence of hidden variables. The essence of the experiment proposed by Bell is as follows.

Let us consider the experimental scheme of EPR. Let there be two photons that can have orthogonal polarizations A and B or $A^{'}$ and $B^{'}$, respectively. Let us denote the probability of observing a pair of photons with polarizations P and Q as ψ^2_{PQ}. Bell introduced the quantity

$$|\langle S\rangle| = \tfrac{1}{2}\left|\psi^2_{AB} + \psi^2_{A'B} + \psi^2_{AB'} - \psi^2_{A'B'}\right|,$$

called the Bell's observable; it has been shown that if hidden variables do exist, then

$$|\langle S\rangle| \leq 1.$$

The possibility of experimental verification of the actual existence of hidden variables has been demonstrated in [4]. The above inequality are called Bell's inequalities. A series of experiments has shown that there is no experimental evidence of the existence of hidden variables as yet, and the existing theories comprising hidden variables are indistinguishable experimentally. In quantum theories with hidden variables, the wavefunction

$$\psi = \psi\left(\lambda_i\right)$$

is a function of hidden variables λ_i.

Let us consider a physical model with gravity background (i. e., the background of gravity fields and waves) playing the role of hidden variables [5-8].

This is only one of many possible versions. We could consider as hidden variables, for example, the electromagnetic background. We shall not discuss here the reasons for this version being unfounded, and we shall not consider it in the present study.

So, let us regard the gravitational background as hidden variables. The gravitational background could be considered negligible and not affecting the behavior of quantum microobjects. Let us verify whether this is correct. The quantitative assessments of the gravitational background influence on the quantum microobjects' behavior have not been performed due to the former having never been examined. The quantum effects are small as well, but their quantitative limits are known and are determined by the Heisenberg inequalitie. Let us demonstrate the gravitational background being random and isotropic to affect the phases of microobjects separated in the space and not interacting. Then we can calculate the correlation factor for these microobjects, hence, the Bell's observable S. Having determined the upper limit for S, we shall get the refined Bell's inequalities taking into consideration the influence of the gravitational background. Comparing these with the experimental data for the Bell's observable, we can verify the correctness of our approach.

By now, hundreds of experimental studies have been performed on measurement of the Bell's observable. It can be positively stated that the experimental value of the Bell's observable has been determined to comply with the expression $|\langle S\rangle| \leq \sqrt{2}$.

Relative oscillations ℓ^i, $i = 0, 1, 2, 3$ of two particles in gravity fields are described by the deviation equations. In this particular case, the deviation equations are converted into the oscillation equations for two particles:

$$\ddot{\ell}^1 + c^2 R^1_{010} \ell^1 = 0, \quad \omega = c\sqrt{R^1_{010}}.$$

It should be noted that relative oscillations of micro objects A and B do not depend on the masses of these, but rather on the Riemann tensor of the gravity field. This is important, since in the microcosm we are deal with small masses. Taking into account the gravity background, the microobjects A and B shall be correlated. It is essential that in compliance with the gravity theory, the deviation equation only make sense for two objects, and it is senseless to consider a single object. Therefore, the gravity background complements the quantum–mechanical description and plays the role of hidden variables. On the other hand, the von Neumann theorem on impossibility of introduction hidden variables into quantum mechanics is not applicable for pairwise commuting quantities (Gudder's theorem [3]). The introduction of hidden variables in the space with pairwise commuting operators is appropriate.

The solution of the above equation has the form

$$\ell^1 = \ell_0 \exp(k_a x^a + i\omega t), \; a = 1, 2, 3,$$

were we assume the gravity background to have a random nature and to be described, similarly to quantum–mechanical quantities, with probabilistic observations. Each gravity field or wave with the index n and Riemann tensor $R(n)$ and random phase

$$\Phi(n) = \omega(n)t = c\sqrt{R^1_{0101}(n)}t,$$

should be matched by a quantity $\ell^i(n)$. Therefore, taking into account the gravity background, i. e. the background of gravity fields and waves, the particles take on properties described by $\ell^i(n)$.

In the present study, we consider only the gravity fields and waves, which are so small that alter the variables of microobjects Δx and Δp beyond the Heisenberg inequality $\Delta x \Delta p \geq h$. Strong fields are adequately described by the classical gravity theory, so we do not consider them here. Let us emphasize that the assumption on existence of such a negligibly small background is quite natural. With this, we assume the gravity background to be isotropically distributed over the space.

Regarding the quantum microobjects in the curved space, we must take into account the scalar product $g_{\mu\nu}A^\mu B^\nu$ of two 4-dimensional vectors A^μ and B^ν, where for weak gravitational fields it is possible to employ the value $h_{\mu\nu}$, which is the solution of Einstein equations for the case of weak gravitational field in harmonic coordinates and having the form:

$$h_{\mu\nu} = e_{\mu\nu}\exp(ik_\gamma x^\gamma) + \\ + e^* \exp(-ik_\gamma x^\gamma),$$

$$g_{\mu\nu} = \delta_{\mu\nu} + h_{\mu\nu},$$

where the value $h_{\mu\nu}$ is called the metrics disturbance, and $e_{\mu\nu}$, the polarization. Therefore, we shall consider the hidden variables $h_{\mu\nu}$ as being the disturbances of the metrics as distributed in the space with the yet unknown distribution function $\rho = \rho(h_{\mu\nu})$. Hereinafter, the indices μ, ν, γ possess values 0,1, 2, 3.

Then the coefficient of correlation M of projections of unit vector λ^i of the hidden variables onto directions a^k and b^n specified by the polarizers is

$$M = \langle AB \rangle = \langle \lambda^i a^k g_{ik} \lambda^m b^n g_{mn} \rangle$$

were i, k, m, n possess 0,1,2,3 and

$$\theta = \left(\overrightarrow{a} \wedge \overrightarrow{b}\right),\ \alpha = \left(\overrightarrow{\lambda} \wedge \overrightarrow{a}\right),\ \beta = \left(\overrightarrow{\lambda} \wedge \overrightarrow{b}\right),$$

and thus

$$M = \tfrac{1}{\pi}\int_0^{2\pi} d\alpha \cos\alpha \cos(\alpha + \theta) = \cos\theta.$$

Then, for $\theta = \frac{\pi}{4}$, we obtain the maximum value of the Bell's observable S

$$\langle S \rangle = \tfrac{1}{2}[\langle AB \rangle + \left\langle A^{'}B \right\rangle + \left\langle AB^{'} \right\rangle - \left\langle A^{'}B^{'} \right\rangle] = \\ = \tfrac{1}{2}[\cos(-\tfrac{\pi}{4}) + \cos(\tfrac{\pi}{4}) + \cos(\tfrac{\pi}{4}) - \cos(\tfrac{3\pi}{4})] = \sqrt{2},$$

which agrees fairly with the experimental data.

The Bell-type inequality in our assumptions (in view of taking into account the gravitational background) should have the form

$$|\langle S \rangle| \leq \sqrt{2}.$$

Therefore, we have shown that the classical physics with the gravitational background gives a value of the Bell's observable that matches both the experimental data and the quantum mechanical value of the Bell's observable. To sum up, the description of microobjects by the classical physics accounting for the effects brought about by the gravitational background is equivalent to the quantum-mechanical descriptions, both agreeing with the experimental data.

From the experiment viewpoint, both of these descriptions are equivalent; however, employing the quantum-mechanical descriptions demands using the quantum mechanical axioms. In addition, plausible arguments should be given that these predictions and interpretation are experimentally distingvishable from existing knowlege.

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